MEMORANDUM

Date: May 28, 2003

To: Kirk Dimmitt, Principal Engineer

From: Richard E Howitt and Siwa Msangi

Subject: An Analysis of the Declaration of Dr. Rodney Smith

Introduction

In the case of IID v. United States, Dr. Rodney Smith submitted a declaration in support of IID's which he purports to have analyzed the economic effect of increased agricultural water efficiency on the Imperial county agricultural economy using a combination of two empirical approaches, statistical regression and cost and profit based impact analysis. As you requested, in the following I summarize my analysis of these approaches.

Statistical Regression.

1. An Aggregate Water Use Regression.

The first approach uses simple aggregate regression estimates to try to explain changes in water use in IID over 36 years. Dr Smith's estimation incorrectly uses linked (endogenous) variables to explain IID water use. When standard statistical measures are used to correct for the mistake, the explanatory ability of the model falls dramatically. Dr Smith claims that his model explains 90.9% of the variation in water use (page 18). When estimated correctly, the proportion of the variation of water use explained by the model falls to the inconsequential level of 48.4% of the variation.

2. Aggregate Employment and Agricultural Revenue Regression

Dr Smith uses an aggregate regression of gross agricultural revenue on gross agricultural employment in Imperial County to infer that a 10% change in agricultural output will cause a 2.6% change in total county employment. Again, the econometric method used is incorrect, but for a different reason. Dr Smith has ignored the possibility that employment and revenue effects are linked over time (autocorrelation). When corrected using a standard method, the average relationship between county employment and agricultural revenues falls to less than half the value proposed by Dr Smith.

Cost and Profit Based Impact Analysis

Despite a clear and correct statement of economic principles at the beginning of the declaration, Dr Smith fails to use two tenets of micro economic analysis, namely marginal analysis and substitution at the intensive and extensive margins in his declaration. The main source of bias in the declaration is the consistent use of average rather than marginal analysis in both the crop impact of increased water conservation and then the labor impact of the crop changes.

1. Marginal Analysis of Potential Conservation Costs

Dr Smith uses seepage recovery and lateral interceptors that are costly conservation measures that have been undertaken in IID under past conservation incentive programs. He states that these costly tail water recovery systems are a "benchmark technology" for the costs of water conservation in IID. However, there is a wide range of alternative on-farm conservation measures that are shown (Payne 2003) to conserve water at a fraction of the cost of tail water recovery systems. In overlooking the simplest and cheapest alternatives, Dr Smith is not taking the conventional economic approach of marginal analysis.

2. The Use of Crop Budget Profit Margins to Predict Crop Acreage Response

The very slim gross margins (gross returns) shown in Dr Smith's attachment 13 are explained by the fact that the budget based costs that are used by Dr Smith incorporate a high proportion of costs priced at "custom" rates, as well as the current crop rent. From economic theory one would expect the net return after rent and custom costs are deducted to be small. In addition, if increased conservation added significantly to the operating costs of crop production, crop rents would adjust to adsorb the cost increases. Thus it is invalid to assume that land would go out of production and produce zero rents, rather than rents adjust downward to adsorb some or all of the increase in cost.

3. The Use of Average Labor Relationships for Marginal Analysis

The labor costs per unit water differs widely among different crops. The low value field and fodder crops, where any marginal adjustment to increased conservation would occur (if at all), have the lowest labor content per unit of output or water use. If the normal marginal approach is used to analyze the labor impacts of increased conservation the result will be very much lower that the impacts averaged over high value crops that are used in Dr Smith's average analysis

4. Optimizing IID Farmers would not currently Voluntarily Adopt Conservation measures.

The ad hoc regression that Dr Smith uses only fits 48% of the variation in water use by IID for the years 1964-2000, when correct statistical methods are used. This raises the question of why there has been a lack of adoption of on-farm conservation by rational economically motivated farmers. It is not at all clear that the terms are settled under which the profits from water sales by farmers in the proposed San Diego transfer are to be allocated among IID members. Given the potential level of fiscal returns from water sales and the current allocation uncertainty, there is a strong rational incentive for farmers not to adopt water reducing on-farm conservation methods. Under current interpretations of beneficial use, on-farm conservation by farmers would reduce their water rights, and possibly their share in any future revenues streams from water sales.

5. Standard Criteria for the Economic Analysis of Water Allocation

The Daubert ruling (Supreme Court June 1993) defined several criteria for scientific evidence. Among the specific criteria defined by the court are two that the methods used in Dr Smith's declaration do not seem to satisfy. The criteria are:

(i) "In determining the admissibility of expert opinion regarding particular scientific technique, court ordinarily should consider known or potential rate of error, and existence and maintenance of standards controlling technique's operation". Later in this memo we will show that Dr Smith's regression analysis, on which his explanation of water use and employment impacts depend, has serious statistical and conceptual errors.

(ii) "Widespread acceptance of scientific theory or technique can be important factor in ruling particular evidence admissible, and known technique that has been able to draw only minimal support within community may properly be viewed with skepticism". Dr Smith's use of aggregate regressions to explain water use and employment impacts is not part of the established techniques used to analyze agricultural resource and cropping effects in past water related studies. The standard approach to such analysis is to construct crop based agricultural production models that reflect the ability of farmers to change cropping patterns and irrigation methods in response to changes in water cost or scarcity.

6. Water Specific Criteria

In 1983 the Bureau of Reclamation issued an updated version of "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies ", henceforth termed "Principles and Guidelines". Economists in the Bureau, and other agencies frequently use the Principles and Guidelines, as a basis for evaluating new or modified public water projects. The criteria defined in the Principles and Guidelines are used as a basis for cost and benefit assessment for a wide range of water projects. Three economic principles are reiterated throughout the document, namely: (i) The use of marginal (as opposed to average) analysis; (ii) the use of opportunity cost rather than nominal values; (iii) the measurement of the differences with and without the project actions being evaluated. Principles and Guidelines have been recently used as a the basis for water reallocation impact studies in the Central Valley Improvement Act Draft Programmatic Environmental Impact Statement (1997), and the ongoing work for the CalFed process and the Snake River reallocation analysis.

The following citation refers to the calculation of national economic benefits (NED), but later in section 1.7.4 it is clear that the same methods must be used to assess regional economic benefits. In section 1.7.2 Principles and guidelines states that: "The cost of the most likely alternative may be used to estimate NED benefits for a particular output if non-federal entities are likely to provide a similar output in the absence of any of the alternative plans under consideration." In the case of assessing the costs conservation activities by IID, correct analysis must consider the cost of those activities that are "the most likely alternative". For cost conscious farmers or managers it is clear that the most cost effective conservation methods will be the most likely to be adopted, and thus these methods should be used as a basis for costing the conservation actions.

In section 2.3.3 the Principles and Guidelines defines the method to be used in evaluating changes in cropping pattern caused by changes in water management. " Project the most probable cropping pattern expected to exist with and without the project" Again, the criterion for correct assessment is that of marginal analysis of the most likely crop changes. The profit-maximizing motive will ensure that the marginal crops changed in response to conservation incentives or requirements will be those that yield the greatest conservation potential for the least cost. Later, we show that Dr Smith's approach of applying the cost of high cost conservation methods over the full range of Imperial crops leads to very different results than the marginal methods required by the Principles and Guidelines.

A Critique of Regression Analysis Done by Dr Smith

Overall Summary of Our Critique

Dr. Smith attempts to use two statistical regression models to support his contention that the water usage patterns of farmers in Imperial county are well-explained by underlying economic and physical factors, and that imposing analysis a higher degree of water use efficiency would do harm to the local economy. We find that both these models are mis-specified from an economic point of view, and that they are analyzed with faulty statistical procedures. This not only negates any importance we can attach to his results, but also undermines the credibility of his argument.

His first statistical analysis used tries to explain changes in water use in IID over 36 years. In this analysis, however, Dr. Smith uses inappropriately chosen variables to explain IID water use, since they are in fact linked with the very quantity he's trying to explain. When standard statistical procedures are used to correct for the mistake, the explanatory ability of the model falls dramatically. Whereas Dr Smith claims that his faulty model explains 90.9% of the variation in water use (page 18), the correctly specified model only explains an inconsequential 48.4% of the variation.

In his second statistical analysis, Dr. Smith does an aggregate statistical regression of gross agricultural revenue on gross agricultural employment in Imperial County to infer that a 10% change in agricultural output will cause a 2.6% change in total county employment. In carrying out this procedure, however, Dr Smith has ignored the fact that employment and revenue effects are closely linked over time, in such a way that residual effects from the previous year are still felt in the variables measured in the current year (a condition known as "autocorrelation"). When corrected using a standard statistical procedure, the average relationship between county employment and agricultural revenues falls to less than half the value proposed by Dr. Smith.

In conclusion, we have determined that Dr. Smith's analysis, in light of these problems, was carried out in a rather careless fashion, and that he failed to carefully think through the theoretical framework for his statistical models. The problems we noted could have been easily avoided with simple diagnostic tests and the statistical variables he chose to use could have been better chosen, on the basis of economic relevance to the issue at hand.

Detailed Critique of Smith's Regression Explaining Water Usage (Appendix II)

<u>The Absence of a Theoretical Basis for the Model Specification.</u>

Although Dr. Smith manages to find a statistical correlation between water usage and the particular variables that he has chosen to use as explanatory factors (such as the amount of rainfall, acres of Sudan grass, etc.), there is no clear theoretical or conceptual framework that would justify the specification of this particular regression model. Standard accepted practice in empirical economics is to define any statistical regression model in a way that is consistent with a behavioral model of water usage by farmers who are seeking to maximize profit through efficient use of agricultural inputs, such as water. By using a conceptual framework of profit-maximization, the researcher avoids including explanatory factors in the model that are extraneous to the issue of interest, and towards the use of explanatory factors that can be justifiably deemed as causative to the quantity being measured. For instance, Dr. Smith uses a general price index for Imperial Valley to explain water usage, whereas a more economically sensible measure to use would be the price of water itself (or some appropriate index thereof). This is the classical distinction between statistical evidence of causation and mere correlation. One may be able to find a strong correlation between recent increases in IID water use and the ownership of SUVs in Imperial County. However, few people would be convinced that SUV drivers were causing higher water use, and there would be no economic model of water usage that would justify that linkage.

Dr. Smith has constructed an ad-hoc statistical model that, on first glance, shows evidence of statistical correlation, but lacks a clear conceptual framework that would explain water use behavior on the part of farmers in Imperial Valley. We also find that this model has serious statistical problems that greatly reduce the validity of the results derived from it.

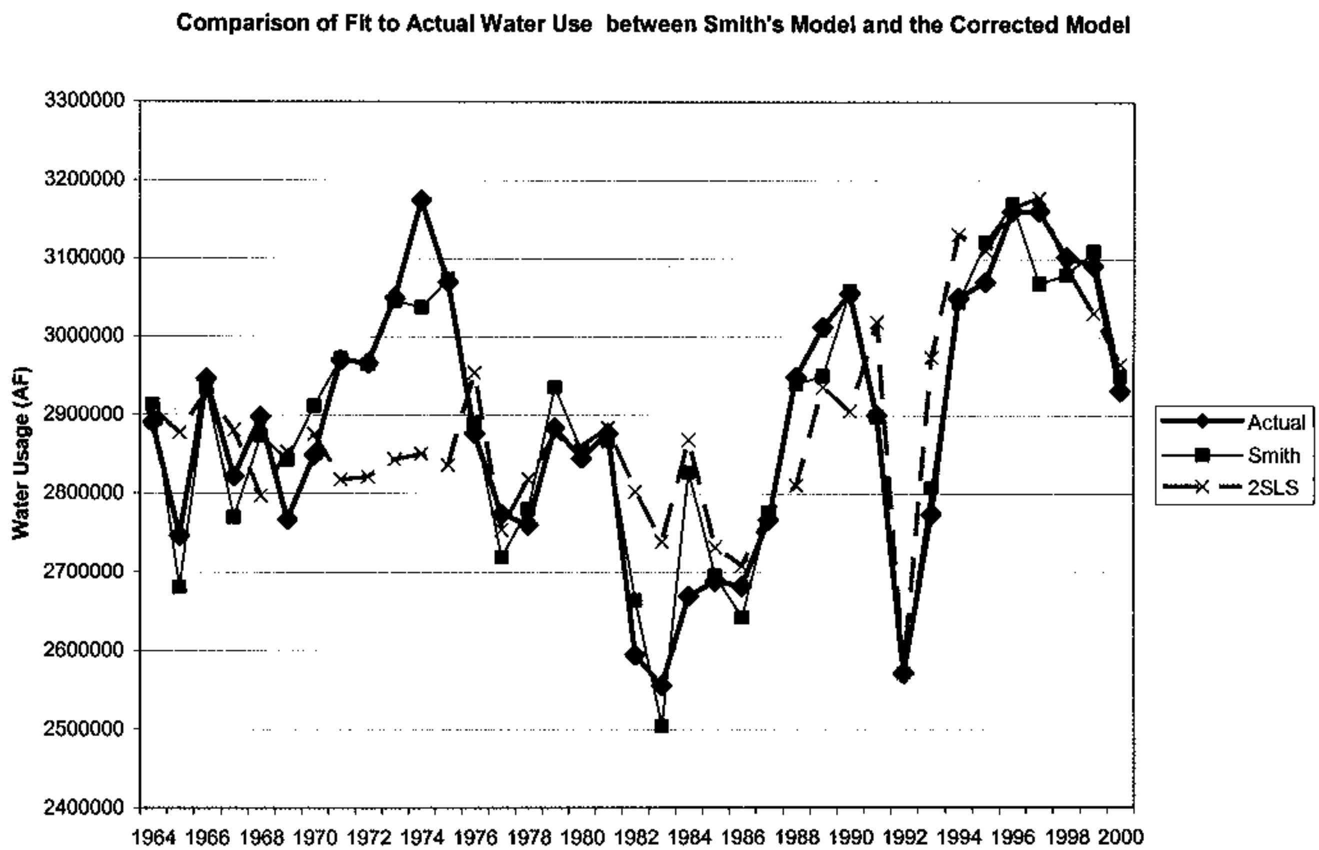
<u>Statistical Problems with the Regression Analysis of Water Usage</u>

Dr Smith uses simple aggregate regression estimates to try to explain changes in water use in IID over 36 years. Dr Smith's estimation model incorrectly uses variables (double-cropped acres and the acreage of Sudan grass) that are co-determined with water use as explanatory factors, whereas they should be chosen to be outside of the control of farmers making water use decisions (i.e., ***exogenous*** to their decisions). Variables, which fail to meet this criterion of exogeneity, are termed ***endogenous*** and are inappropriate to use as explanatory factors in such a statistical model, as they are jointly determined with the quantity that is being explained. This is similar to trying to use the number of ice cream parlors to explain the change in ice cream sales. The number of ice cream parlors and the quantity of ice cream sales may be highly correlated, but the number of parlors is determined by the same economic forces that increase the demand for ice cream, and does not have any explanatory power in of itself. In the same way, the acres that are double-cropped or planted to Sudan grass are determined jointly with the amount of water used for irrigation, and cannot be separated from the overall decision process that determines the production behavior of the farmers that are observed in the data. By comparison, his other explanatory variables – such as rainfall, salinity in the Colorado River, whitefly, prices and costs and the net acres of land available in Imperial – can be considered to be outside of the control of the water users (and therefore exogenously given to them).

When standard statistical measures are used to correct for the mistake, the explanatory ability of the model falls dramatically. Dr Smith claims that his model explains 90.9% of the variation in water use (page 18). When estimated correctly, the proportion of the variation of water use explained by the model falls to the inconsequential level of 48.4% of the variation.

The difference in predictive ability between the faulty and corrected models (labeled "2SLS") is shown in the figure 1.below.

Figure 1.



Now we will explain, in detail, how these statistical problems were diagnosed and then corrected, using standard empirical procedures. From this analysis, we will be able to see the bias that Dr Smith created in his results by ignoring this problem.

Diagnostic Tests Used on Smith's Regression

We have pointed out that Dr. Smith has ignored the problem of using simultaneously determined (endogenous) variables to explain water usage. We can test for the presence of a possible ***endogeneity*** problem by performing a standard statistical procedure, known as the Wu-Hausman test. Taking data on these same variables from the plots in the declaration for the period over which Dr. Smith analyzed, we can reproduce his regression results very closely, as shown below.

Dep Var = WaterUse	Coef.	t	P>|t|
Explanatory Variables			
Rainfall	-51714.1	-6.82	0
NetAcre	1.604988	1.16	0.255
DoubleCrop	2.799094	5.04	0
Sudangrass	3.743163	5.79	0
PriceIndex	353.1616	5.52	0
CostIndex	-641.467	-4	0
Salinity	375.8587	1.62	0.117
WhiteFly	-100218	-1.53	0.136
constant	1953716	3.31	0.003

Number of obs = 37
F(8, 28) = 34.69 (Prob > F = 0.0000)
R-squared = 0.9084 (Adj R-squared = 0.8822)
Durbin-Watson d-statistic(9, 37) = 2.125051

Now we can apply a standard diagnostic to the variables DoubleCrop and Sudangrass, to determine whether or not they are in fact endogenous to the underlying water usage decision process. This test is called the Wu-Hausman test (Davidson & MackKinnon, 1993) and proceeds as follows:

(1) We first regress, in turn, each of the variables that we suspect are endogenous on the rest of the (presumably) exogenous variables (Net Acres, PriceIndex, CostIndex, Rainfall, Salinity & Whitefly)

$$\begin{Bmatrix} Sudangrass \\ DoubleCrop \end{Bmatrix} = \beta_0 + \beta_{Ac}(NetAcre) + \beta_{Pr}(\Pr ice) + \beta_{Cst}(Cost) + \beta_{Rn}(Rain)$$

$$+ \beta_{Sl}(Salinity) + \beta_{Wf}(WFly) + \varepsilon$$

(2) We save the residuals (i.e. the calculated ε terms) from these regressions and then use them in place of the (endogenous) variables in the original regression

$$WaterUse = \beta_0 + \beta_{Sudan}\hat{\varepsilon}_{Sudan} + \beta_{DCrop}\hat{\varepsilon}_{DCrop} + \beta_{\Pr}(\Pr ice) + \beta_{Cst}(Cost) + \beta_{Ac}(NetAcres) + \beta_{Rn}(Rain) + \beta_{Sl}(Salinity) + \beta_{Wf}(WFly) + \varepsilon$$

(3) We evaluate the coefficients of these constructed "variable" to see if they're significantly different from zero – if they are, then we would reject the null hypothesis that they are exogenous explanatory variables (i.e. we would determine that they are, indeed, endogenous explanatory variables) $H_0: \beta_{Sudan} = 0, \beta_{DCrop} = 0$

By following this procedure, with these data, we obtained the following results:

(1) test → $H_0: \beta_{Sudan} = 0$
F(1, 28) = 33.51 (Prob > F = 0.0000)

(2) test → $H_0: \beta_{DCrop} = 0$
F(1, 28) = 25.41 (Prob > F = 0.0000)

Given the critical value of 7.64 for the F-statistic (and the zero P-values), we would be well justified in rejecting the null hypothesis for both of these variables. The inescapable conclusion is that Sudangrass acreage and the Acres Double-cropped are endogenous to the econometric model presented by Dr. Smith, and are not valid explanatory variables for Water Usage in Imperial.

In contrast, if we undertake the same diagnostic procedure for the variable measuring the number of Net Acres, we would obtain the test results shown below

test → $H_0: \beta_{Acres} = 0$
F(1, 28) = 1.35 (Prob > F = 0.2553)

Since the F-statistic is less than the critical value, this variable passes the test for exogeneity. In other words, we would not be able to reject the null hypothesis and can consider the variable Net Acres to be truly exogenous and valid for use as a regressor in the statistical model.

Similarly, the variable for price index also passes the exogeneity test with an F-statistic of 2.05 and a p-value of 0.1628. This is not at all a surprising result, since we would expect that the farmers would take market prices as given and exogenous to their production decisions.

Statistical Procedures Used to Correct the Problems in Smith's Regression

We can correct for endogenous variables in a regression by applying a 2-stage statistical regression procedure. In this procedure, called Two-Stage Least Squares (2SLS), we first try to explain the levels of Sudangrass acreage and double-cropped acres with chosen "instrument" (truly exogenous) variables, and then use those predicted levels of the endogenous variables from the 1st stage as exogenous explanatory variables in the second stage to explain the water usage levels. In other words, the first stage consists of estimating the statistical model below:

$$(1)\ Y_{DoubleCrop} = \beta_0^1 + \beta_{Pr}^1(Price) + \beta_{Cst}^1(Cost) + \beta_{Rn}^1(Rain) + \beta_{Sl}^1(Salinity) + \varepsilon_1$$

$$(2)\ Y_{Sudangrass} = \beta_0^2 + \beta_{Pr}^2(Price) + \beta_{Cst}^2(Cost) + \beta_{Rn}^2(Rain) + \beta_{Sl}^2(Salinity) + \varepsilon_2$$

Followed by the 2nd stage statistical regression

$$WaterUse = \beta_0 + \beta_{Sudan}(\hat{Y}_{Sudangrass}) + \beta_{DCrop}(\hat{Y}_{DCrop}) + \beta_{Ac}(NetAcres) + \beta_{Rn}(Rain) + \beta_{Wf}(WFly) + \varepsilon$$

Following this procedure, we obtain the results shown in the table below

Dep Var = WaterUse	Coef.	t	P>|t|
Explanatory Variables			
DoubleCrop	1.646465	1.51	0.142
Sudangrass	5.63397	2.99	0.005
WhiteFly	-394036	-2.93	0.006
NetAcre	-2.08917	-0.79	0.438
constant	1953716	3.31	0.003

F(8, 28) = 4.64 (Prob > F = 0.0046)
R-squared = 0.4844 (Adj R-squared = 0.4199)

In this modified regression procedure the coefficients remain largely unchanged in sign from the original regression (except for Net Acres, which is, however, now insignificant) – however the overall explanatory power of the regression is now greatly reduced. The F-statistic shows that the overall significance of the regression is only slightly above the critical level of 3.23, and the statistic that measures the overall goodness-of-fit of the model (R^2) is greatly reduced in value from the original regression. So now, having correctly addressed the endogeneity problem in Dr. Smith's econometric model, we show that his previous results are invalid and mis-represented the relationship between water usage and the variables that he used to explain it.

But we also know that there are other important explanatory variables that have been omitted from both Dr. Smith's original econometric model (and this corrected one) that might explain water usage – such as the presence, extent and types of irrigation technologies and conservation methods used. Their omission, in fact, leads to another source of bias in Dr. Smith's original statistical model (known as "omitted variable bias" in the statistical literature), but which cannot be addressed by the corrected version we have shown here. We have simply tried to show the bias that was caused by incorrectly specifying the model, using the same explanatory factors that Smith used.

Conclusion

In summary, we have found that Dr. Smith has failed to produce a statistical model that can reasonably explain the usage of water in Imperial Valley. Mis-specifying his statistical model and ignoring the serious statistical problems creates a bias in his results that causes him to greatly overstate the explanatory power of his regression model and its ability to fit the observed pattern of water usage in Imperial Valley. As such, his model results cannot be use to estimate the impact of any one of his explanatory factors on overall water usage, or to reliably predict future water usage in Imperial.

Detailed Critique of Smith's Regression Explaining Average Employment (Appendix III)

The Absence of a Theoretical Basis for the Model Specification.

The statistical employment model presented by Smith seems to be much too sparse and ad-hoc in its specification to be able to measure anything of real importance. Economic theory (and even common sense) would indicate that there are many other possible factors that would explain total employment in Imperial Valley, besides just crop revenue – especially considering that we're considering total employment and not just employment within the agricultural sector (which is a puzzle, in of itself). Among the variables that he should have included in his statistical model are measures of investment and public sector growth over the previous five or so years in Imperial, as well as a time indicator that would pick up the effect of a particular year (or span of years) on employment levels (due to some significant political or economic event that might have occurred). As it is, his model is lacking in any economic intuition that can justify its structure and specification. The lack of theoretical basis for his employment model erodes Smith's claim of direct causality and only points to circumstantial correlation rather than any type of underlying causality.

Statistical Problems with the Regression Analysis of Total Employment

Dr. Smith's statistical model purports to predict the effect of a decrease in crop revenue on total employment in Imperial Valley. While Dr. Smith has attached a great deal of importance to the results of his analysis, we will show that, in this instance, he has overlooked yet another important statistical problem that is embedded in his model, and which causes him to overstate the impact indicated in his results. In this instance, the problem that Dr. Smith has neglected to address is that the model variables may be systematically linked over time (a condition know as *autocorrelation*) that would lead to a bias in the error structure of his statistical model. Since he is taking a time-series of data, there is the real (and often realized) possibility that the "shocks" or events that occur in one period are not fully 'worked out' or dissipated by the time that you make the next observation in the following year. In other words, the sampling error in this period may contain some residual of sampling errors that carried over from the previous years. This is referred to as ***autocorrelation*** and results in biased test statistics, if not corrected – so one cannot reliably evaluate the overall statistical significance of the regression or of any particular variable in that regression.

Diagnostic Tests Used on Smith's Regression

Whereas Dr. Smith calculated the very important Durbin-Watson statistic in his Water Usage regression, he either failed to test for it or report it in this case. This statistic is used as a diagnostic in time-series analysis, to measure the degree to which sampling errors from one period might be related to those in the next. The Durbin-Watson statistic for Dr Smith's equation is 0.529, which is close enough to zero to indicate that there is a positive and statistically significant autocorrelation effect embedded in the error structure of his statistical model.

Statistical Procedures Used to Correct the Problems in Smith's Regression

Given the significance of this statistic, immediate action is called for to obtain results that can be interpreted reliably. However, there are standard procedures for dealing with this problem. We corrected Dr. Smith's regression by using a transformation applied by Prais and Winsten (1954) to these kinds of statistical problems. It involves (iteratively) getting a reliable estimate of the underlying autocorrelation coefficient of the error process, and then using that estimate to construct a transformation that is applied to the explanatory variables in the regression. The resulting regression estimates from this procedure can then be interpreted and evaluated reliably for their statistical significance. The results of this procedure are given below:

Dep Var = log(Total Employment)	Coef.	t	P>|t|
Explanatory Variables			
Log (Crop Revenue)	0.113538	2.67	0.012
Year	0.0188789	7.68	0.000
constant	-28.24859	-5.77	0.000

F(8, 29) = 7886.73 (Prob > F = 0.0000)
R-squared = 0.9982 (Adj R-squared = 0.9980)

The Durbin-Watson statistic from this corrected regression is 1.286, which is just below the critical value of 1.309, and indicates that most of the autocorrelation has been corrected for. This is greatly improved over the previous value of 0.529, and gives credible results. Now we see that the coefficient for the variable that measures the logarithm of crop revenue is more than halved in value, compared to Dr Smith's regression results. This indicates that he greatly over-stated the average effect that a decline in crop revenue would have on total employment in Imperial Valley. Of course, to obtain an accurate measure of the employment effect of changes in the small proportions of water use in this case, we should not use any values averaged over crops, but only those labor values for the marginal crops that may be changed by water conservation.

Conclusion

In summary, we find that Dr. Smith has failed to produce a satisfactory statistical model that can represent the true economic process driving total employment in Imperial Valley. His current model specification is much to sparse to measure any causative factors of real significance to employment levels, and the implementation of his analysis is faulty and overlooks important statistical problems. This combination of faults should convince us that it is best to abandon the enterprise that Dr. Smith is attempting to prosecute with the aid of a highly mis-specified and poorly implemented statistical model.

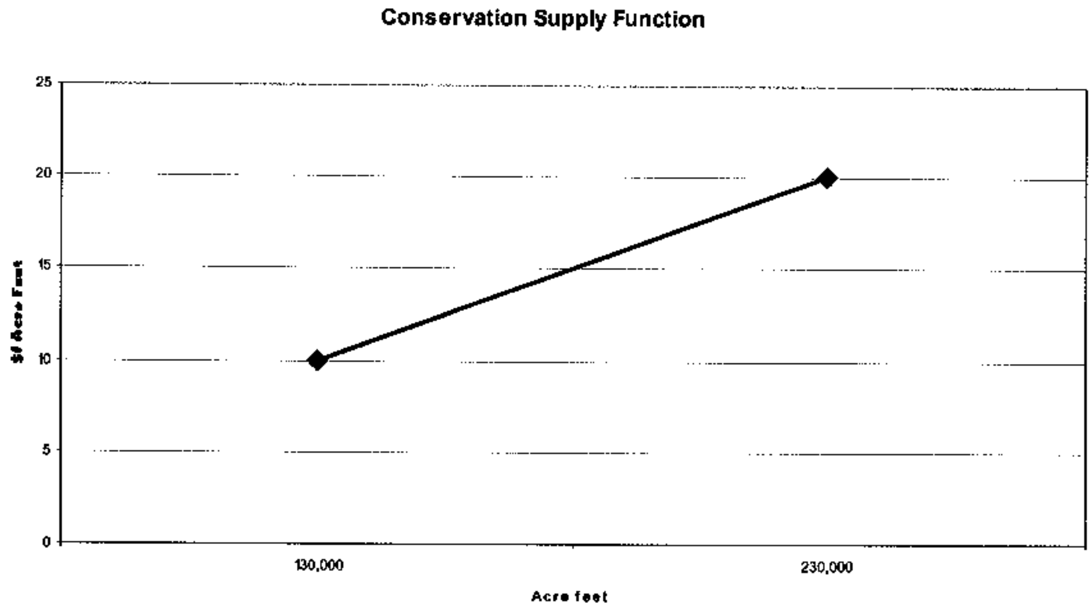
Cost and Profit Based Impact Analysis

1. Considering the Full Range of Conservation Methods and Costs

By defining the highly expensive pump back systems installed by the Metropolitan- IID agreement as the "benchmark conservation technology" Dr Smith ignores the array of much cheaper "on farm" conservation methods that Imperial farmers can use to achieve a reasonable level of tail water and conserve substantial amounts of water with no impact on crop yields. A wide range of conservation measures have been defined and costed by Payne and Brown (Payne 2003). Payne and Brown list nine conservation approaches that can be applied to the two dominant irrigation methods used in IID. Payne and Brown estimate that 60% of IID is irrigated by Border strip methods, while the remaining 40% uses Furrow irrigation. The district average tail water percentage is estimated at 25% (Rhoades 2003). Using the data in the summary table in section 6, we see that application of a combination of conservation methods can reduce the tail water from 25%- 15% for a cost per acre-foot of $10 or less. Taking the average water use per acre as approximately 6.3 acre feet per acre (Jensen and Walter, 2002) the potential quantity of water conserved at this cost is 130,000 acre-feet per year. A similarly conservative calculation for the furrow irrigated area yields a maximum cost of $20 / acre-foot and a potential additional quantity of 100,000 acre-feet. While we recognize that some farmers in IID are already successfully implementing these conservation measures, the quantities available from additional conservation is based on the district average tail water, and thus already incorporates the effect of those farmers who are practicing farm level conservation.

The first part of the supply function for conserved water in IID is shown in figure 2. Additional water quantities can be conserved at a higher cost using on-farm and system conservation methods that are more costly. However these two points on the water conservation supply function demonstrate that the on-farm conservation costs shown by Dr Smith in Attachment 12 of Appendix III on page 66 are certainly not the lowest cost alternative, and therefore not the marginal cost or “the cost of the most likely alternative” required under the Federal Principles and Guidelines.

Figure 2.



2. The Use of Budget profit Margins to Measure the Impact of Cost Changes on Crop Production

The previous section shows that growers would respond to reduced supplies with low cost conservation measures that, at the above costs calculated by Payne and Brown, would pay for themselves in reduced water costs. Nonetheless, even assuming a $15/acre-feet increase in water cost, the crop and income impacts that Dr Smith proposes are far too high.

Dr Smith's conjecture on page 8 of appendix B states that: "An uncompensated conservation obligation requiring a $15/AF(01$) increase in IID's water rate, for example, would significantly reduce the economic viability of irrigated agriculture in Imperial valley. When crop prices are low, such as they were in the year 2000, for example, the impact of the water price increase will push more acreage over into the realm of no longer being economically viable. Depending on economic conditions in crop markets, such a loss of irrigable acreage could reach 30% and would include reductions in the acreage for all crops grown"

Dr Smith's profit calculations in attachment 13 of appendix III are remarkable in that so many crops make so little profit in so many years. It reminds one of the joke about car dealers who claim to be selling cars below their cost but making up the loss in volume. How can this occur when Dr Smith calculates the profits based on County Extension budget costs and published prices? The answer is simple if one critically examines the components of the budget costs. The UC Extension budgets for Imperial use "custom operation" rates as a basis for many of the operation costs, and add crop rent into their estimate of production costs. Using standard neoclassical economic theory we would expect the profit to be allocated among the services and fixed inputs and a return to management and risk bearing. However given the high proportion of custom operations in the higher valued crops, an economist would expect that the return to management and risk to be low or close to zero depending on current prices. The proportion of crop costs that are based on custom operations are shown in figure 3. The proportion of production costs varies between 80% - 20% with the higher proportions being concentrated in the high value crops.

Thus, Dr Smith's use of the very low net return values from the budgets to suggest that high value and cost crops will cease production when faced with a $15 increase in water cost is incorrect. Figure 4 shows the percentage of total production costs that are composed of (non-labor) water costs and crop rent. For the fourteen crops considered, in all but four crops (Klein grass, Sudan grass, Wheat, & Bermuda grass) the rental cost is twice the water cost. This shows that for most crops there is ample ability for changes in water costs to be partially or full offset by reductions in crop rental costs.

If one uses the standard supply response approach that is based on increases in the marginal cost of a crop, it is clear that only the low value crops can be affected by a change in water cost.

Figure 3.

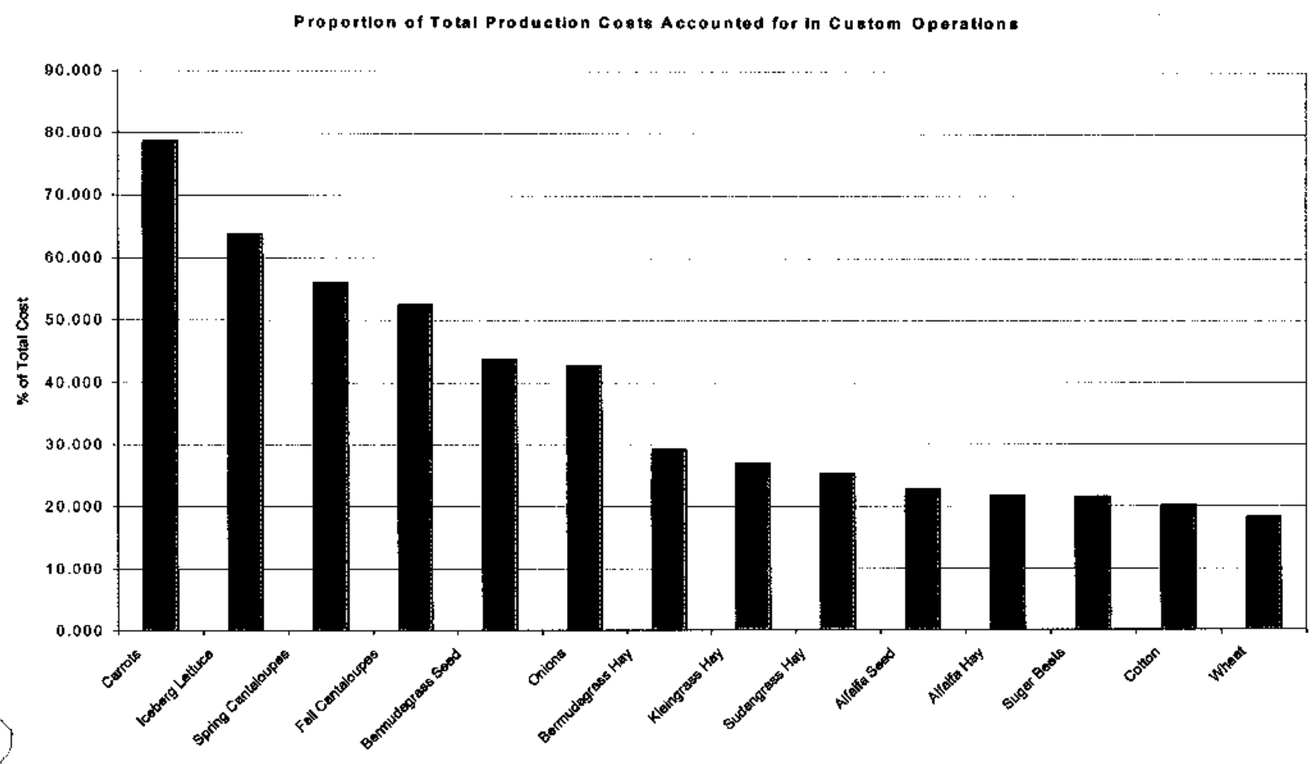
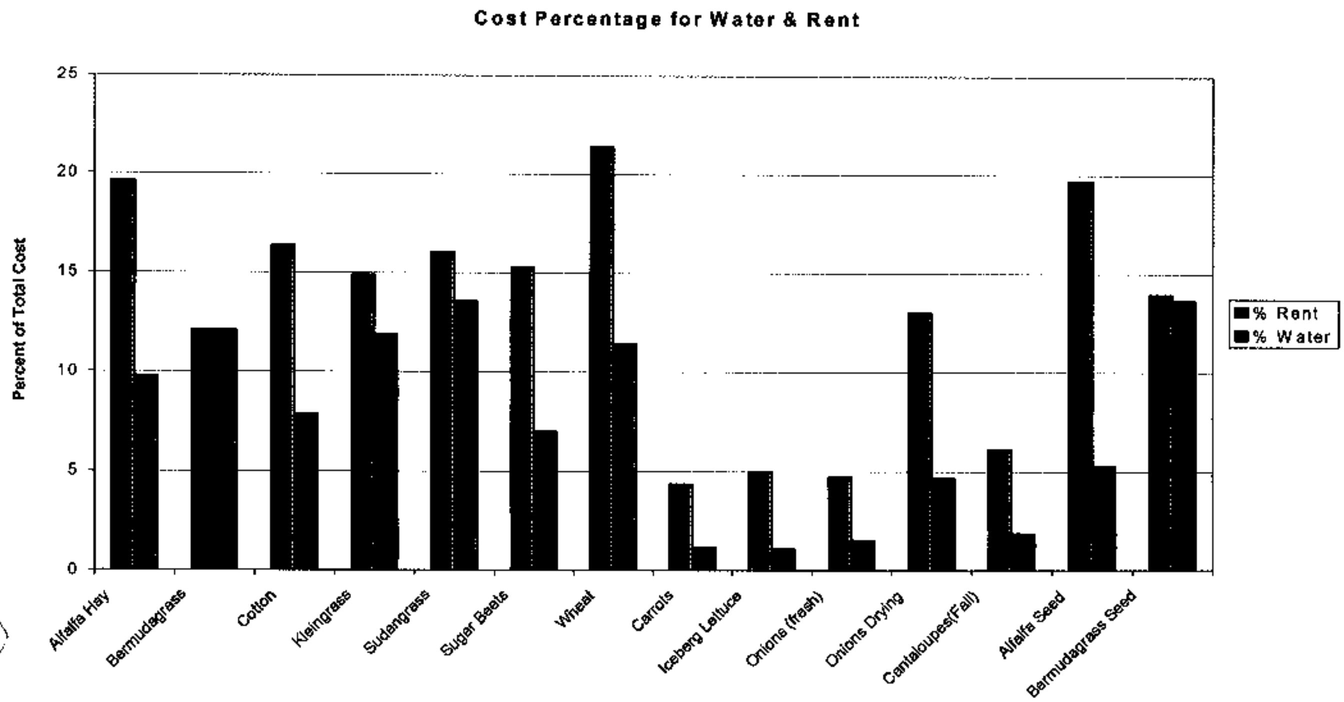
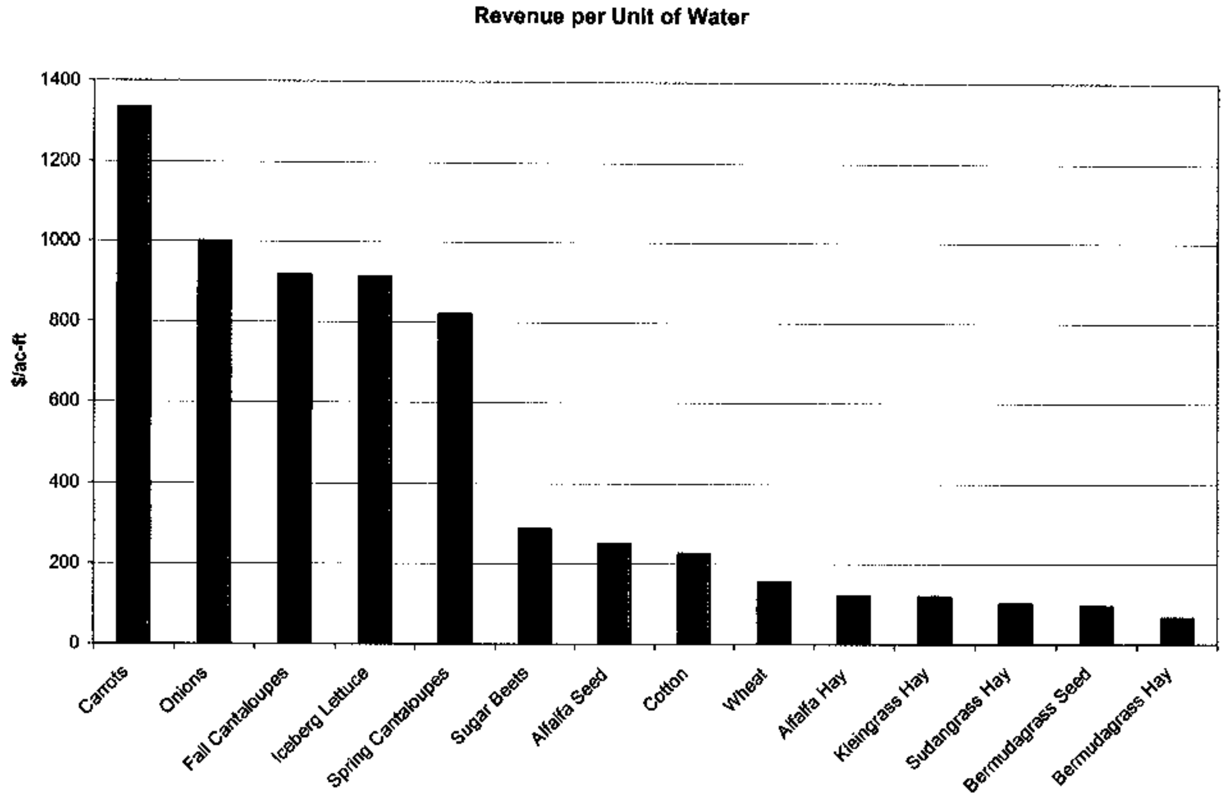


Figure 4.



In addition, the first change when faced with higher conservation costs would be for the rental values to adjust downward. It follows from profit maximizing behavior and common sense that landlords will lower rental rates before abandoning land, as Dr Smith suggests they will.

Figure 5.



Dr Smith's conjecture is based on average values rather than the standard approach of marginal analysis. The average approach ignores the wide differences in water use per acre among Imperial crops, and also the wide difference in revenue per acre-foot. The top five revenue producing crops average $997 per acre foot, while the bottom five revenue crops, which are also the ones with largest acreage in Imperial have an average revenue per acre foot $100.79, almost one tenth that of the high value crops. One does not need an econometric analysis to see which crops profit-maximizing farmers may choose to reduce in acreage.

Dr Smith lists the percentage acreage impact from a $15/acre foot increase in water costs in column three of attachment 13 in appendix III. Presumably this is the result of calculating the effect of a $15 in crease in unit water cost on the total cost of the crop and then using an unstated or implied supply response elasticity to measure the percentage change in the acres grown of those crops. Dr Smith concludes that the net result of a $15 per acre-foot water charge increase could be a 30% reduction in irrigated acres.

There are several problems with this conclusion.

(i) It ignores any potential for the important substitution at the intensive level whose importance Dr Smith correctly notes in his introduction. The average analysis does not account for the low proportion of crop costs that water represents for the high value crops, and thus their unresponsiveness to water prices. Figure 4 shows a large difference between the high and low water cost proportions. The five crops with the highest proportional water cost average 11.5% of variable costs in water, while the five crops with the lowest proportional water cost average 1.65%, approximately one seventh of the high cost proportion group. This high cost proportion that will be most responsive to changes in water cost, is also largely the same low value crop group that has low revenues per unit water. There is therefore a double reason why farmers will respond to conservation or cost increases by substituting among these crops.

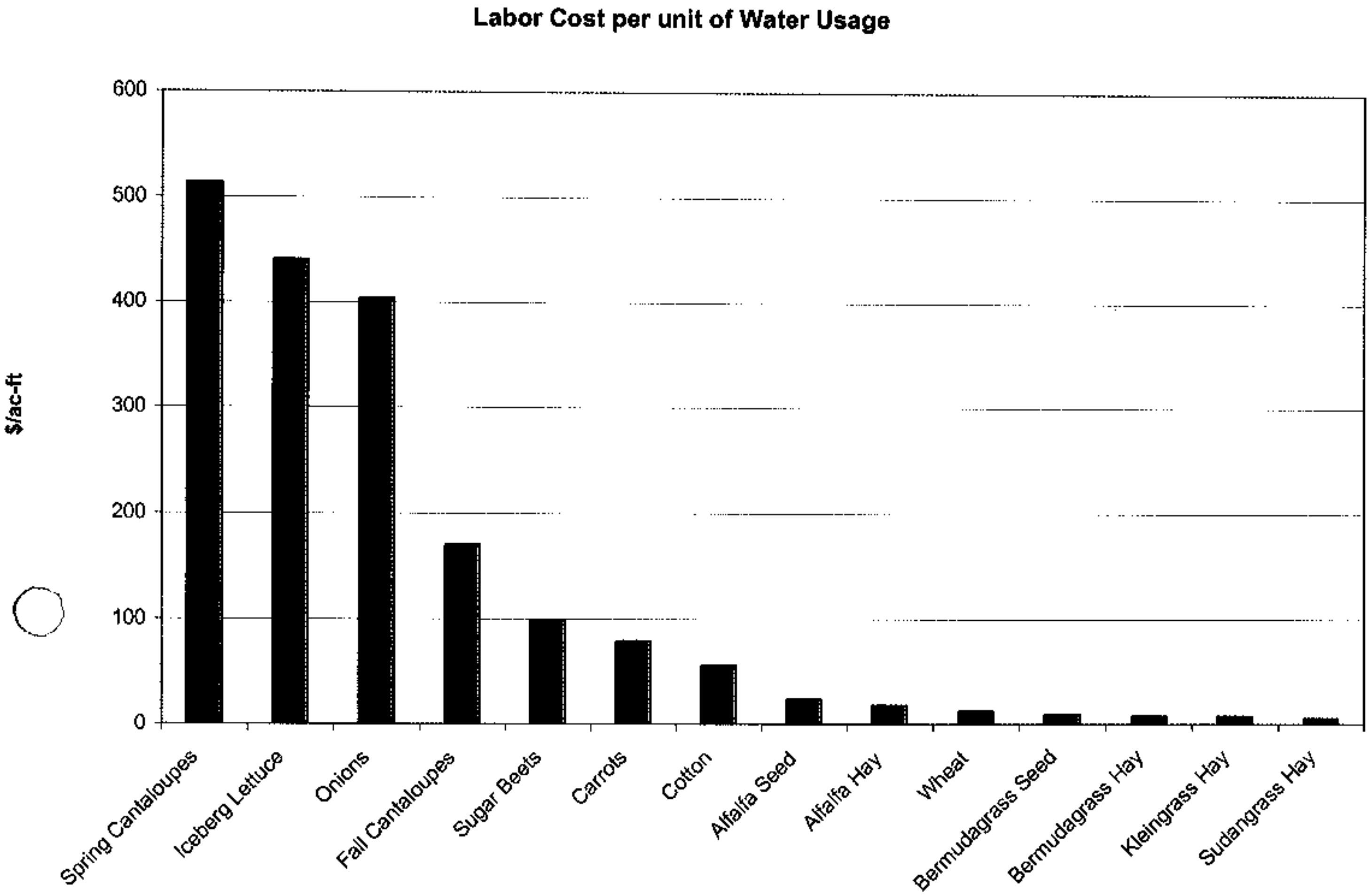
(ii) The unresponsive high value crops are those that generate the most county income and labor input per unit of water.

(iii) Thus taking an average approach substantially over-estimates the income and employment impact of changes in water conservation costs.

3. <u>The Labor Impacts of Water Cuts</u>

Dr Smith's analysis of the labor impacts of the changes in crop acres is based on a regression of the Imperial county agricultural employment on gross agricultural revenue. There are two sources of bias inherent in this analysis. First the revenue impact of marginal adjustments to water will be in those crops that generate low revenue per unit water, see Figure 5. Second, based on the principle of marginal analysis, figure 6 below shows that the low value crops, which assuming the $15/AF increase are those that would be changed, have a low labor impact per unit water.

Figure 6.



The labor expenditures per unit of water differ widely. The top five crops for labor revenue per unit water average $325 per acre foot, but the low impact crops at $8.60 per acre foot only average 3% of the high labor impact crops. Use of average labor impact values will therefore greatly distort any labor impacts of changes in marginal agricultural production.

The Cross Border Migration effect

Another factor that reduces the labor impact of water reductions on the Imperial economy is the number of short-term farm laborers who migrate across the border for work, and remit their wages to Mexico. Martin (2003) notes this phenomenon, but we are currently unable to quantify the proportion of agricultural laborers who are cross border migrants.

4. Optimizing IID Farmers would not currently Voluntarily Adopt Conservation Measures.

When correct statistical methods are used, the ad hoc regression that Dr Smith uses only explains 48% of the variation in water use by IID for the years 1964-2000. This raises the question of why there has been a lack of adoption of low cost on-farm conservation by rational economically motivated farmers. Despite the reference to Mr. Silva's declaration (see Smith page 5), it is not at all clear that the terms are settled under which the profits from water sales by farmers in the proposed San Diego transfer are to be allocated among IID members. The expectations of future water sales revenue, provides a clear reason why a profit maximizing farmer would not adopt these conservation measures in the current uncertain climate.

Assuming a uniform distribution of the net revenues from an annual sale by IID farmers of 100,000 acre feet at $250.0 per acre foot, the value of such a sale amounts to an increase in the annual return per acre foot of $6.65 or approximately $38.60 per acre irrigated. This net return equals or exceeds the average net returns for alfalfa, Sudan grass, and wheat calculated by Dr Smith for 1995-2000 prices in Attachment 13 of Appendix III.

Given this average level of fiscal returns and the current allocation uncertainty, there is a strong rational incentive for farmers not to adopt water reducing on-farm conservation methods that would, under current interpretations, reduce their water rights, and no doubt their share in any future revenues streams from water sales.

In their study "Market Transfers of Water Rights" Meyers and Posner note that the doctrine of beneficial use confers an implicit property right. "The appropriation system creates an incentive to develop water where the value of the developed water will exceed the cost of development, for in that case the appropriator will acquire a valuable property right. If, in accordance with our previous suggestions, the right is then transferable, the initial use of the water can subsequently be altered so as to bring about the most productive possible employment of the resource" (page 39).

Summary:

(i) The water use regression used by Dr Smith is misspecified and invalid. When it is estimated using standard econometric methods such as 2SLS the fit is not persuasive.

(ii) The regression that Dr Smith used to relate aggregate employment to agricultural revenues is badly biased. When the estimation is performed correctly, the average labor effect that results is half of what Dr Smith proposes.

(iii) By defining the highly expensive pump back systems installed by the Met IID agreement as the "benchmark conservation technology" Dr Smith ignores the array of much cheaper "on farm" conservation methods that Imperial farmers can use to achieve a reasonable level of tail water and conserve substantial amounts of water. The expectations of future water sales revenue, provides a clear reason why a profit maximizing farmer would not adopt these conservation measures in the current uncertain climate.

(iv) By using average agricultural revenue to labor impact coefficients, the labor effects are greatly exaggerated. The crops that will change water use have both low revenue and labor use costs per unit of water. Marginal analysis will show a much lower impact, if any, on employment.

(v) Use of budget based net returns ignores the effect of custom operation costs, and ignores the crop rent adjustment that would occur with a long term change in the cost structure.

Clearly there is a wide difference between the average and marginal income and employment effects of water conservation in IID. Thus a non-standard analysis based on average impacts, such as presented by Dr Smith will greatly overstate both the income and employment effects of marginal reductions in the IID water supply. A standard agricultural economic analysis that takes account of marginal substitutions at the intensive and extensive margins by changing the irrigation technology and crop mix were done, it would show the degree of over-estimation in the declaration by Dr Smith.

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